ME 8843
Advanced Mechatronics
Instructor: Professor I. Charles Ume

Power Rectifiers
Outline

• Motivation
• Rectification Technologies
• Diode Rectification
• Implementation
• Applications
Motivation

- Early experiments with Direct Current (DC) power relied on Leyden jars (rudimentary batteries) which had to be recharged via manual labor (e.g. grad students).
- Due to efficiency and safety reasons, Alternating Current (AC) is used for providing electrical power.
- A means to convert AC to DC is required - called Rectification.
Rectification Technologies

- Electromechanical
- Synchronous rectifier
  - Used a motor attached to metal contacts that switched direction of current flow in time with AC input voltage
- Motor-generator set
  - An AC motor coupled to a DC generator
- Electrolytic
  - Two different material electrodes suspended in an electrolyte provide a different resistance depending on current flow
- Mercury arc rectifier
  - A sealed vessel with mercury in it provides a DC power by transmitting electricity through ionized mercury vapor
  - Capable of power on the order of hundreds of kilowatts
- Vacuum Tube
  - Capable of high voltages, but relatively low current
Mercury Vapor Rectifiers

From steel manufacturing plant in Germany

Advanced Mechatronics, Georgia Tech
Types of Rectification

- **Half Wave:**
  - Negative components of sine wave are discarded

- **Full Wave:**
  - Negative components are inverted

![Sine wave](image1.png)
![Half-wave rectified](image2.png)
![Full-wave rectified](image3.png)
Diode based Rectification

• Diodes provide a compact, inexpensive means of rectification

• Can create rectifiers from multiple diodes or purchase integrated module
• While the output of the rectifiers is now DC (current only flows in one direction), the output oscillates.
Poly-phase rectification

- Industrial settings usually have 3-phase power available for machines
- Rectifying 3-phase power results in a DC voltage with less ripple
Output Voltage

- Full wave rectification will produce a voltage roughly equal to
  \[ V_o \approx \sqrt{2} V_{i,RMS} \]
- In practice, there will be a small voltage drop across the diodes that will reduce this voltage
- For accurate supplies, regulation is necessary
Output Ripple

- Output ripple will always be present in the circuits shown above
- Amplitude of ripple can be reduced by adding a smoothing capacitor
- Capacitor and load (shown here as a resistor) form low pass filter with time constant $\tau = RC$
- Time constant should be much longer than one ripple
- For a given ripple amplitude capacitor size (in microfarads) given by

$$C = \frac{I_{\text{load}}}{f V_{\text{rip}}} \times 10^6 \ (Half \ wave) \quad or \quad C = \frac{I_{\text{load}}}{2f V_{\text{rip}}} \times 10^6 \ (Full \ wave)$$

- $f$: line frequency
- $I_{\text{load}}$: Load Current
- $V_{\text{rip}}$: Amplitude of ripple voltage

NOTE: Voltage rating of the capacitor must be $> 1.4*V_{\text{out}}$ and large capacitors should have bleeder resistors for safety!
Applications

• DC Power supplies
  – Used to provide DC power to drive loads

• Radios
  – Used to rectify received radio signals as part of AM demodulation
  – Signal to be transmitted is multiplied by a carrier wave
  – Diode in receiver rectifies signal

![Diagram of AM Demodulation Process]
Applications

• **Light Dimmer**
  – Sends unrectified or half wave AC power through light bulb

• **Automobile Alternators**
  – The output of the 3-phase AC generator is rectified by a diode bridge
  – More reliable than DC generator
References